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ON THE FECUNDATION OF OVULES IN ANGIOSPERMS.

By JOHN KRUTTSCHNITT, New Orleans, La.

In the year 1823 Mr. Amici observed that on the stigma of certain plants, the pollen-grains emitted tubes; by degrees a theory was evolved, which attributed to these "pollentubes," as they were termed, quite important functions, and at present they are considered the principal factors in the fertilization of the ovules of angiospermous plants.

Among professional botanists it is now put down as a dogma that the nucleus, which is believed to exist in the pollen-grain, is carried down by means of the tubes in question, of which it is said to occupy the extreme end through the style to the micropyle and thence to the embryo-sac of the ovules, where it is brought in contact with the oosphere, thereby fertilizing the latter; or, in other words, that the pollentubes after their formation on the stigma, maintain their separate formation; that they enter as such the tissues of the style, vegetate and lengthen, taking their nourishment from the tissues they traverse, and that on arriving at the head of the ovarian capsule they grope their way to the micropyle of the ovule, and at last to the embryo-sac of the same.

The April number of 1881, page 263, of the *Journal of the Royal Microscopical Society of London*, contains a synopsis of a paper published by Professor Detmer of Jena, in one of the German botanical periodicals, "On the Course of Pollentubes in Angiosperms." The description which he gives of the appearance of the ovules and their appendages is exact. I have followed him over the same field, but I have failed to discover any pollentubes, or anything like them, in the ovary. To enlighten myself I entered into correspondence with the professor, sending him some of my preparations—calling particularly his attention to the ovules of *Cereus* and requesting him to point out to me the whereabouts of the pollentubes. In answer he informed me in substance, that he had no time to re-examine the question.

In illustration of the remarks in this paper I submit fifteen slides of preparations of ovaries of various plants as specified hereafter. I selected chiefly those in which the emission of pollentubes on the stigma may be readily observed. This phenomenon is by no means of general occurrence; on the contrary it forms the exception.

In examining attentively these preparations any one must be struck at once by the apparent difficulties the pollentubes would have to overcome on their course towards the micropyle and the embryo-sac of the ovule; in most of them the difficulties seem to become impossibilities, *e. g.*, *Cereus*, *Papaver*, *Pyrola*, *Monotropa*, and even taking Mr. Detmer's paper for a guide, I could not solve the problem.

The ovary of *Cereus* contains at least three thousand ovules; the style is a slender tube six to eight inches long, the interior of which is lined with conducting tissue, leaving only quite a small orifice, certainly not large enough to allow the passage of three thousand pollentubes if they should choose the stylar canal for that purpose; nor do the tissues of the style show any trace of the presence of pollentubes; neither transverse nor longitudinal sections reveal them. I will here remark that the style of *Cereus* before the flower has expanded, and before any pollen-grains have fallen on the stigma, offers the same appearance as it does in the expanded flower; the conducting tissue is there, but it does not contain as yet any fovilla granules.

In *Papaver* the stigma is a starlike shield adhering closely to the apex of the ovary which contains as many parietal placentæ as there are rays on the stigma, say about twelve; both faces of the free placenta are closely beset with ovules; but there is no trace of pollentubes.

In *Pyrola elliptica* and in *Monotropa uniflora*, and in fact in all the Ericaceæ I have had occasion to examine, the formation of the ovary is such that it seems to offer an impenetrable barrier to the passage of pollentubes. The reniform massive placenta projects from a stout central column, and in its free parts is closely studded with anatropous ovules, their orifice being in immediate contact with the surface of the placenta.

In the large order of Compositæ the micropyle of the anatropos ovule points in the opposite direction from the stigma; the difficulty of the pollentubes finding their way to the micropyle of the ovules, Mr. Detmer solves in the following way: "The conducting tissue of the style consists of two closely adjacent lines which separate when they reach the cavity of the ovary, passing down the two sides and uniting again beneath the basilar anatropous ovule."

In plants where the ovary is free as in *Cuphea* (Lythraceæ) the pollentube would have to overcome still greater obstacles. Mr. Detmer is of the same opinion, but does not indicate how they could be removed, confining himself to state: "The least favorable structure for the conduction of the pollentubes is presented by the free central placentation."

After having stated the obstacles the pollentubes would have to overcome in their course towards the micropyle, we will now discard the teachings of the books and simply describe what an examination of sections of ovaries reveals to us; these revelations will also solve in a natural and easy way the problem of fertilization.

In *Cereus* (Cactaceæ) the stigma is covered with pollen-grains, emitting tubes which insinuate themselves amongst the papillæ of the stigma; the tubes discharge their contents, fovilla of the pollen-grains, which may easily be traced in cloudy streaks and aggregations amongst the fibrillæ of the conducting tissue of the style; the conducting tissue on arriving at the apex of the ovarian cavity spreads itself over the walls of the same, follows the funiculus, which on its central surface is covered with minute papillæ; the ovule, which bends over on the funiculus, is thus brought in easy contact with the papillæ just mentioned, and the substance of the pollen contained therein is absorbed by the papillæ of the micropyle of the ovule, the fertilization of which is thus accomplished.

Mr. Detmer also makes mention of the papillæ on the funiculus; he says they serve as guides to the pollentubes in their course towards the micropyle, converting them thus into a kind of Ariadne's thread for the pollentubes to find their way in the labyrinth of ovules and funiculi in the ovarian cavity of *Cereus.*

In *Papaver*, bundles of conducting tissue descend from the under surface of the sessile stigma at the extremity of the rays through the walls of the ovary to the base of the free parietal placenta, permeating it with the substance of the pollen brought down by the conducting tissue from the stigma; both faces of the placenta are covered with anatropous ovules, the micropyle being thus brought in contact with the tissues of the placenta.

The fertilization of the Compositæ is effected without any difficulty, the micropyle of their anatropous ovules being brought in contact with the fertilizing element carried down from the style by the conducting tissue also mentioned by Mr. Detmer.

Two plants, *Lepidium Virginicum* and *Capsella Bursa-pastoris* have been frequently pointed out to me as being best suited for the study of the process of fecundation, and for the demonstration of the entrance of the pollentubes into the micropyle. I have examined both plants, but have failed to verify the fact stated; my observations on the contrary lead me to believe that those who say they have seen the entrance of the pollentube into the mycropyle must have misunderstood the phenomena observed by them. I have appealed to my informants for enlightenment, which was, however, withheld for want of time to prepare sections.

The opinion which at present prevails regarding the fertilization of the plant ovule seems to have been moulded on the *modus operandi* of the fecundation of the animal ovum. The human ovum, after its descent through the Fallopian tubes into the uterus, is brought there in contact with the male element; the germinal vesicle after fecundation has become the fundamental cell out of which the human body is evolved. Different conditions obtain in the fertilization of the plant ovule. Before the act of fecundation, the plant ovule from a minute vesicle on the wall of the ovary has become already an object in all respects similar, in shape at least, to the mature seed, even the markings on the integuments, when they exist in the mature state, are represented; the act of fecundation does therefore not furnish the fundamental cell for the evolution of the ovule, but seems to be necessary only to promote its further development and to the formation of the embryo in the embryo-sac out of the female element therein contained by bringing it in contact with the male element, which at the proper time pervades the whole ovary, and of course the ovule.

The results of my investigations may be summed up as follows: The pollentubes as they are found on the stigma lose their separate existence; they discharge their contents amongst the papillæ of the stigma, which may be considered the aggregate head of the fibrillæ of the conducting tissue which is found in the style and in the various parts of the ovary, impregnating thus the whole ovary as an entirety with the substance of the pollen which has been absorbed by the papillæ of the stigma. The existence of the nucleus in the pollen-grain is problematic, and its fusion with the oosphere in the embryo-sac has not become an observed or a demonstrable fact; therefore, by ignoring it science will not be wronged.

In a foot-note in Sach's Treatise of Botany, French translation, third edition, p. 662, Paris, 1873, I find the following statement in translation:

"In placing pollen-grains in an artificial medium, the production of pollentubes may be pushed very far, and if we place further amongst these tubes whilst in an active growing state, from the same plant, some ovules detached from the placenta before fecundation, some of the ovules, at least, will be fecundated, and shortly after, the first stages of development of the embryo may be observed; this development is not of long duration for want of nourishment."

In this instance fecundation seems to be induced by the absorption of the substance of the pollen by the ovules. Is this not direct proof that the fusion of the problematical nucleus with the oosphere is not necessary to produce fecundation?

MEMORANDUM OF FIFTEEN SLIDES OF VEGETABLE PREPARATIONS TO ILLUSTRATE THE PROCESS OF FECUNDATION IN ANGIOSPERMS.

1. Cereus grandiflora—transverse section of ovary.
2. Cereus grandiflora—transverse section near base of style.
3. Cereus grandiflora—ovules and stigma with pollentubes.
4. Oenothera biennis, sections of ovary.
5. Oenothera biennis, stigma with pollen-grains and tubes.
6. Portulaca oleracea, section of ovary.

7. Portulaca oleracea, stigma with pollentubes.
8. Papaver somniferum transverse section of ovary.
9. Zinnia (Compositæ) flower with ovary.
10. Zinnia (Compositæ) flower with ovary.
11. Capsella Bursa-pastoris—ovaries in various stages of development.
12. Pyrola elliptica. Ovules.
13. Monotropa uniflora—transvers and longitudinal sections of ovary.
14. Cuphea (Lythraceæ). Ovary.
15. Trifolium pratense—ovary, style and stigma, united.

These preparations are put up in camphor and chloroform water after having been cleared in caustic soda, and bleached in chlorinated soda—stained with violet aniline and Bismarck brown.

[Note.—The preparations mentioned in the above memorandum are held, for the present, by the Secretary of the Society, and will be loaned for study to any member of the Society who desires to use them. D. S. K.